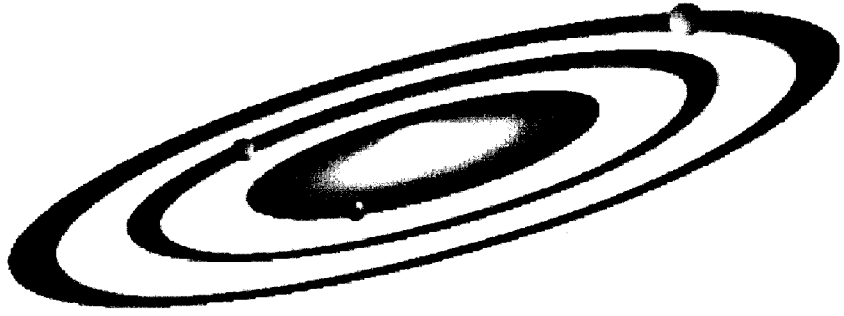
DRAFT

Genesis
NASA Discovery Program
Solar Wind
Sample Return
Solar Nebula
Payload Canister
Concentrator
Silicon Collectors
Spacecraft



GENESIS

SEARCH FOR ORIGINS

Presented at:
European Geophysical Society
XXIV General Assembly
The Hague, The Netherlands, 19-23 April 1999

By:
Chet Sasaki
Genesis Project Manager
Jet Propulsion Laboratory / NASA

GENESIS
SEARCH FOR ORIGINS

Presentation Outline

Part 1: Science

Part 2: Payload Features

Part 3: The Mission System

DRAFT

PART 1: Science

DRAFT

Mission Objective

To collect Solar Wind Materials in Order and To Evaluate the Collected Material To Address the Processes Involved in the Origins of the Solar System.

- **Place a Spacecraft Outside the Earth's Magnetosphere**
- **Expose Ultra-Pure Materials (Collectors/Concentrator)**
  - **Capture solar wind for two years**
  - **Solar wind ions and elements collected be above the "noise floor" of the collectors ⇒ clean collectors**
- **Return the Imbedded Solar Wind Samples to Earth**
- **Analyze the Samples With State-of-the-Art Laboratory Instruments**

Why Genesis?

Examples of Major Planetary Science Questions for Which Genesis Will Provide Information

(1) How Can We Explain the Great Diversity of Planetary Objects?

(2) What Makes Earth Different From Its Planetary Neighbors?

(3) What Is the Sun Made Of? Are We Made of the Same Stuff?

GENESIS
SEARCH FOR ORIGINS

Fundamental Hypotheses

- The Diversity in Planetary Objects Is Primarily a Consequence of Conditions, Events and Processes in the Solar Nebula
- The Elemental and Isotopic Compositions of Planetary Materials Are a Fossil Record of the Solar Nebula
- Solar Nebula Models Will Be Verified by Predicting Planetary Material Compositions Starting With a Solar Nebula Composition Based on Genesis Data
- Similarly, Genesis Isotopic Data Will Be Used to Verify Terrestrial Planet Atmospheric Evolution Models
- Solar Isotope Data (Especially O) From Genesis Test Whether 1-3 AU Materials Are the Same As in the Sun

GENESIS
SEARCH FOR ORIGINS

Science Collection/Measurement

- **Measure Elemental & Isotopic Abundances of Solar Wind Ions.**
  - **Measurement Priorities**
  - **Accuracies or Precisions Required**
- **Collect Separate Samples for Each of 3 Solar-Wind Regimes: Low Speed, Coronal Hole, and Coronal Mass Ejections**
  - **Required to Determine Solar Photosphere Composition From Solar Wind**
  - **Necessitates Monitoring of Solar Wind Type By Spacecraft**
- **Provide a Reservoir of Solar Matter for Future Analysis**
  - **Sets Philosophy on Collector Area**
  - **Requires Long-Term Curation**

Prioritized Measurement Objectives

(1) O isotopes.
(2) N isotopes in bulk solar wind.
(3) Noble gas elements and isotopes.
(4) Noble gas elements and isotopes; regimes.

(5) C isotopes.
(6) C isotopes in different solar wind regimes.
(7) Mg,Ca,Ti,Cr,Ba isotopes.
(8) Key First Ionization Potential Elements
(9) Mass 80-100 and 120-140 elemental abundance patterns.
(10) Survey of solar-terrestrial isotopic differences.
(11) Noble gas and N, elements and isotopes for higher energy solar particles.
(12) Li/Be/B elemental and isotopic abundances.
(13) Radioactive nuclei in the solar wind.
(14) F abundance.
(15) Pt-group elemental abundances.
(16) Key s-process heavy elements.
(17) Heavy-light element comparisons.
(18) Solar rare earth elements abundance pattern.
(19) Comparison of solar and chondritic elemental abundances.

GENESIS
SEARCH FOR ORIGINS

Accuracies/Precision of Measurements

- **Elemental Accuracy (2 σ Limits)= ±10% of the Number of Atoms of Each Element per cm^2 on the Collector Materials**
- **Isotopic Precision (2 σ Limits On the Relative Number of the Different Isotopes of an Element Compared to a Terrestial Reference Standard)**
  - **O, Mg, Ca, Ti, Cr, Ba** ±0.1%
  - **C** ±0.4%
  - **N** ±1.0%
  - **Noble Gases** ±1.0%
  - **^{78}Kr, ^{124}Xe, ^{126}Xe** ±3.0%
  - **Others** ±1.0%

DRAFT

GENESIS
SEARCH FOR ORIGINS

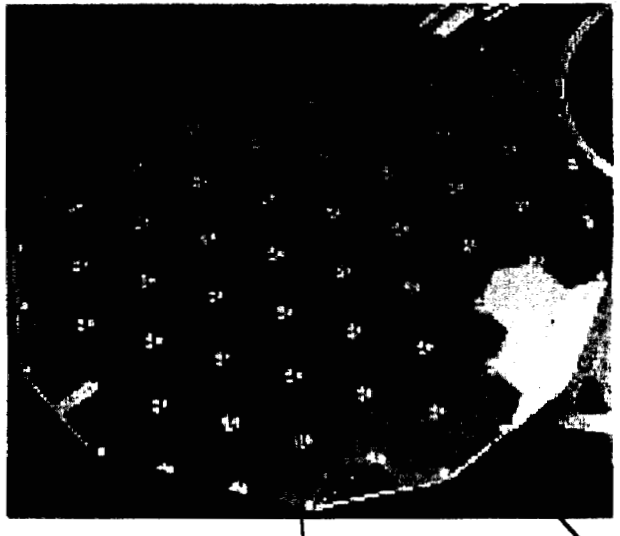
Collector Materials

The Collector Materials Are the "Containers" Which Will Capture and Hold the Solar Wind Samples. Therefore:

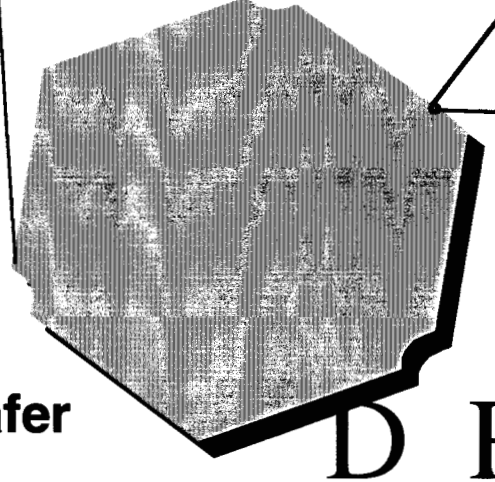
- **Must Be Pure Enough:**
  - **Design Goal Is Signal to Noise Ratio > 100**
  - **Critical Requirement SNR > 10**
- **Must Be Clean Enough:**
  - **Surface Contamination < 2 yr Solar Wind Fluence for any element**
  - **If Some Surface Contamination Does Occur, There Must Be Methods for Removing It Prior to Analysis**
- **Must Lend Itself to the Desired Analytical Technique**
- **Different Materials Work Best for Different Elements**

D R A F T

Contamination

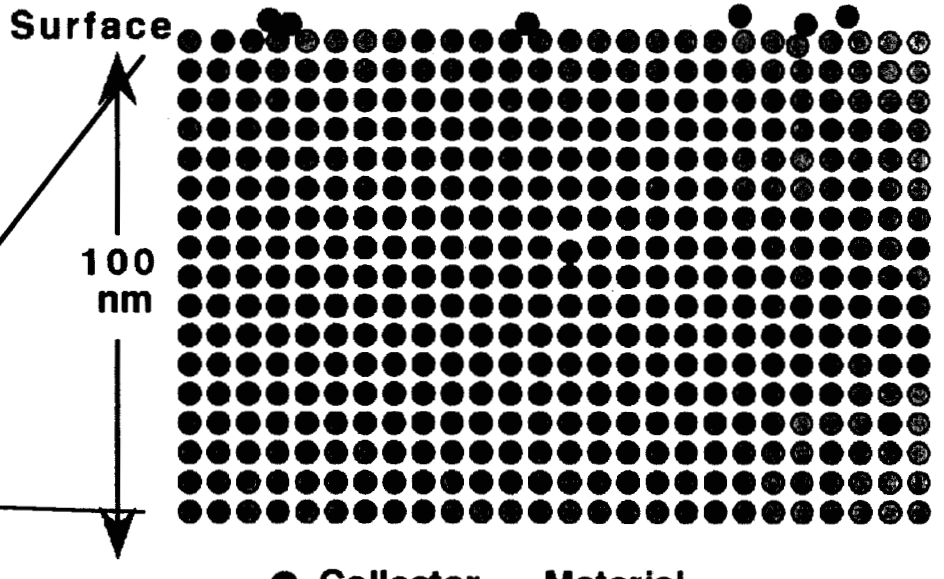


Array



Wafer

Schematic View of Top 100 nm



- Collector Material
- Implanted Solar Wind
- Contaminants

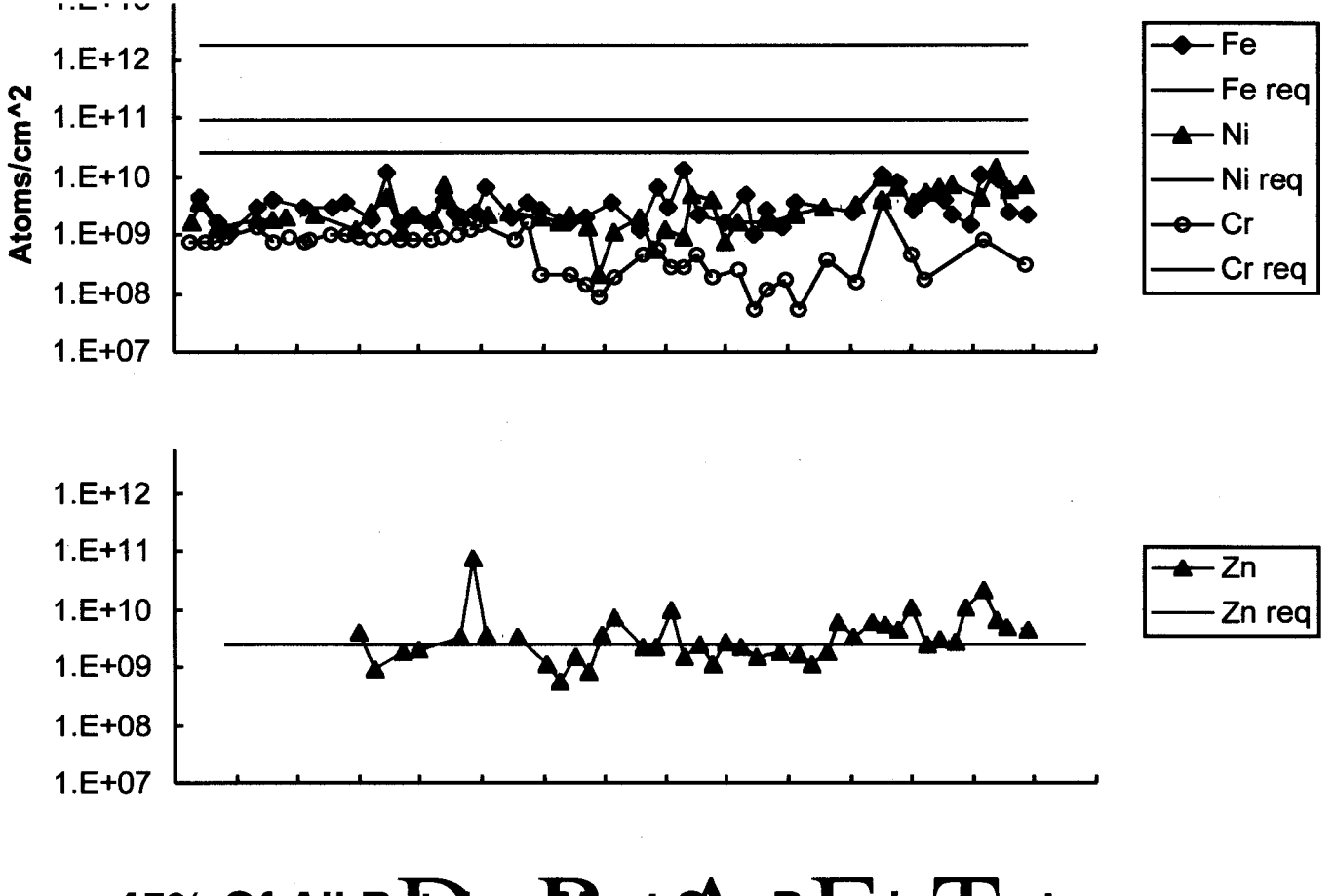
DRAFT

GENESIS
SEARCH FOR ORIGINS

Start With Clean Collectors

- **We Can Consistently Meet or Exceed Requirements**

Example Process Control of Si Wafer Surface Contamination



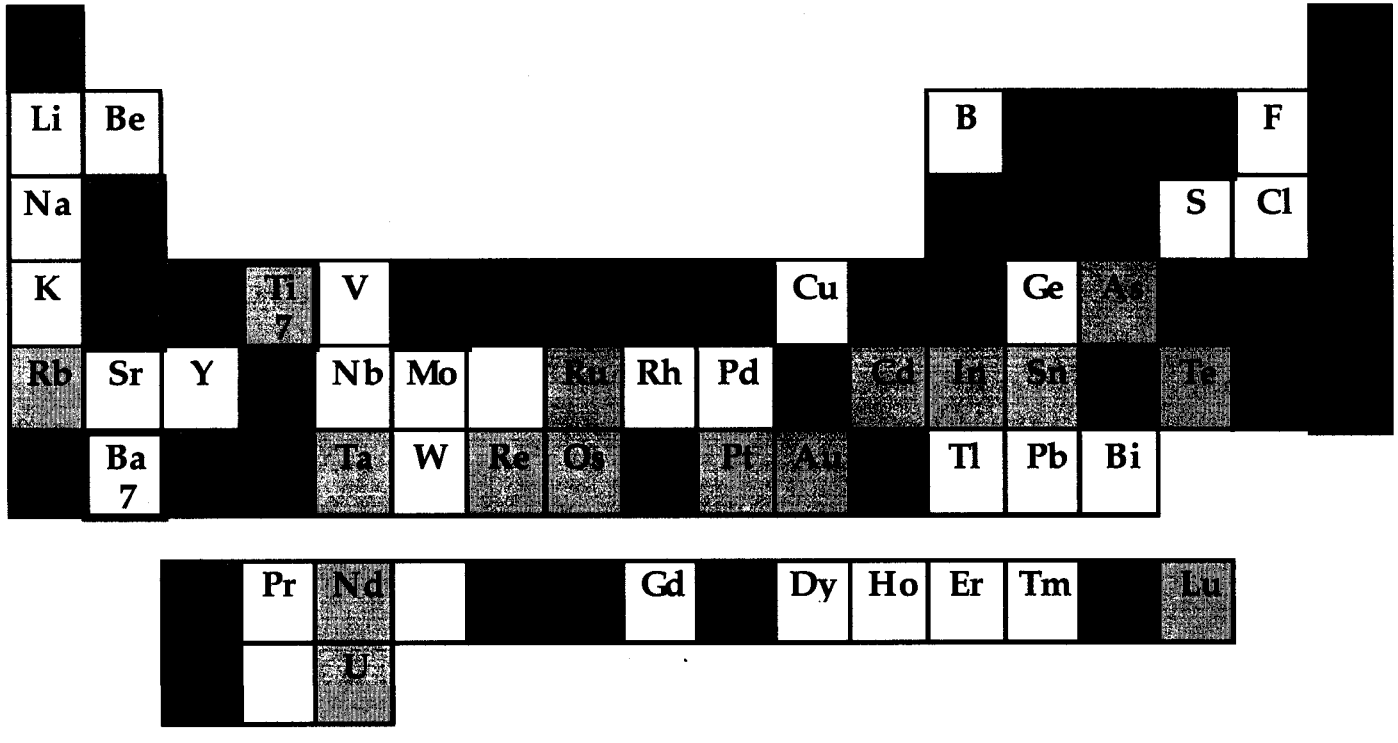
~ 45% Of All Batches Meet Our Requirements

GENESIS
SEARCH FOR ORIGINS

Bulk Purity of Elements*

*Bulk Purity in Collectors, Mostly Based on Silicon

Green = SNR > 100
Blue = SNR > 10
Blank = SNR > 10 expected



DRAFT

GENESIS
SEARCH FOR ORIGINS

Material Selection vs. Measurement Objective

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
MATERIAL																		
Diamond	CD	BD												CX				
SiC	CD	BD										CL		CX				
AuOS	C				BX	BX		B			BX						B	
AlOS			CD	CD														
SOS					CX	CX			D									D
Si	BD	BD			D	D	C	CL	CD	L		CX		B	CL	CL	CL	CD
Sapphire					BX	BX		CL	CX	L		CL		B	B	CX	CL	CX
Ge								CL	CX	L					CX	CX	CL	CX
Vitreloy			BX								CX							
Al			BD	BD					BD									
Pd on Pt													C					

C = Selected Material D = Documented Purity X = Planned but not yet documented
B = Backup L = Objective with List of Elements; Partial Documentation

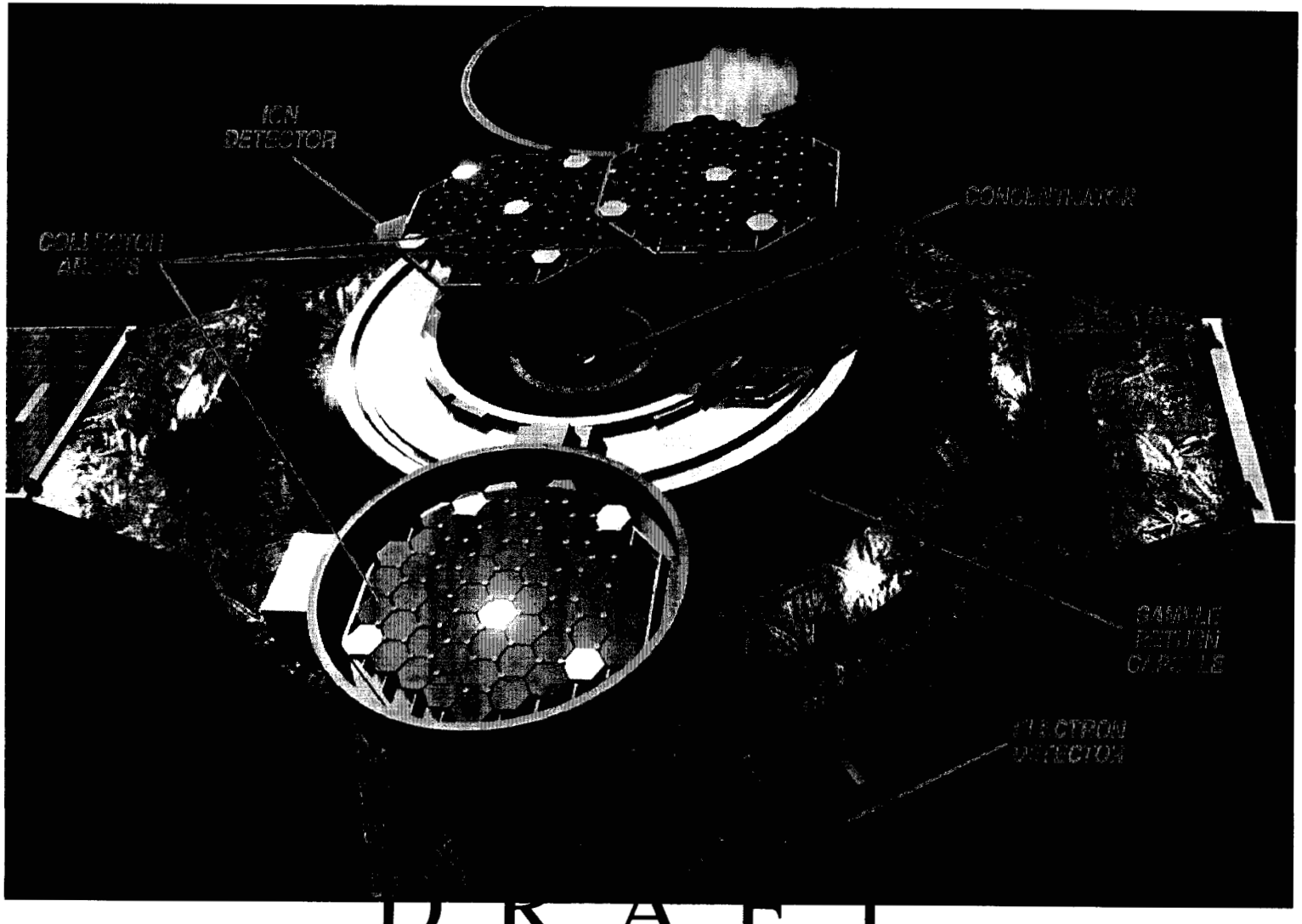
PART 2: Payload Features

- General Payload Desciption
- Canister and Collector
- Concentrator

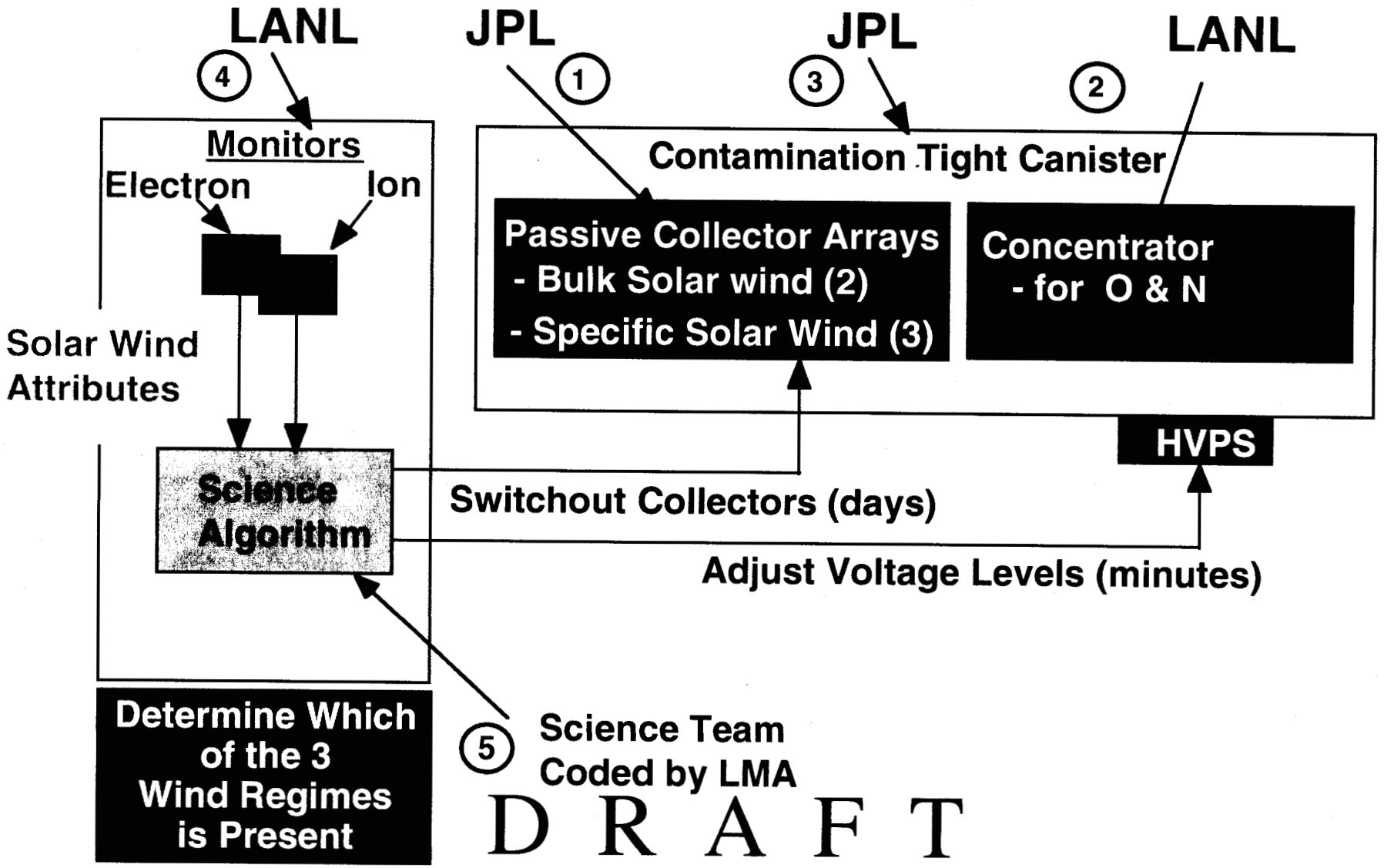
DRAFT

GENESIS
SEARCH FOR ORIGINS

The Genesis Spacecraft/SRC/Payload



Components of the Payload



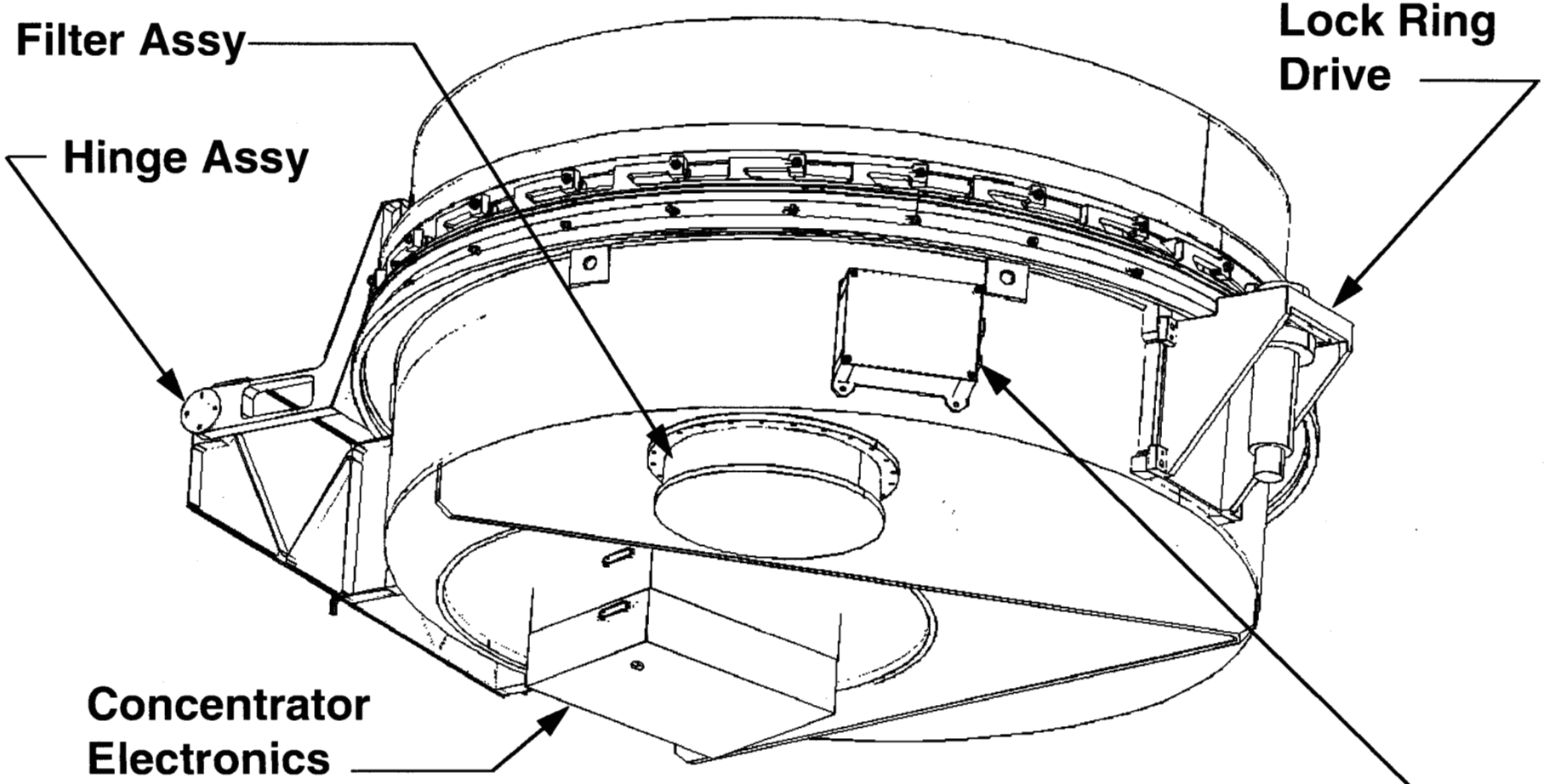
DRAFT

Collector Array Design

- Bulk Solar-Wind Collector Area > 0.6 m^2
- Each of 3 Special-Regime Collector Areas > 0.3 m^2
- Collector Array Materials Not To Exceed 200° C for Si and 250° C for Other Materials
- Material From Each Array Shall Be Uniquely Identifiable.
  - In Case Material is Dislodged
- Radioactive Nuclei Collectors Exposed in Lid of SRC.

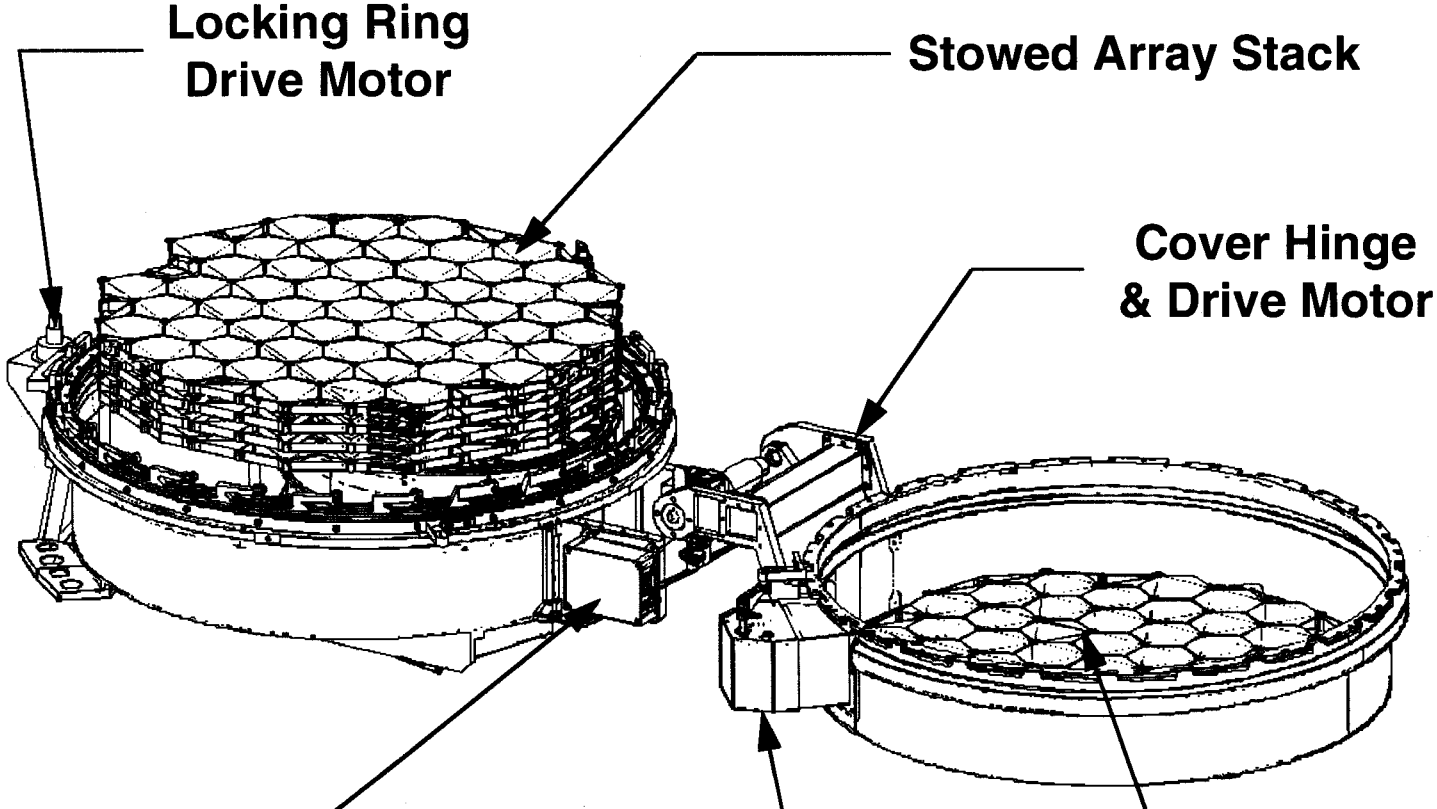
GENESIS
SEARCH FOR ORIGINS

Integrated Canister CAD Model



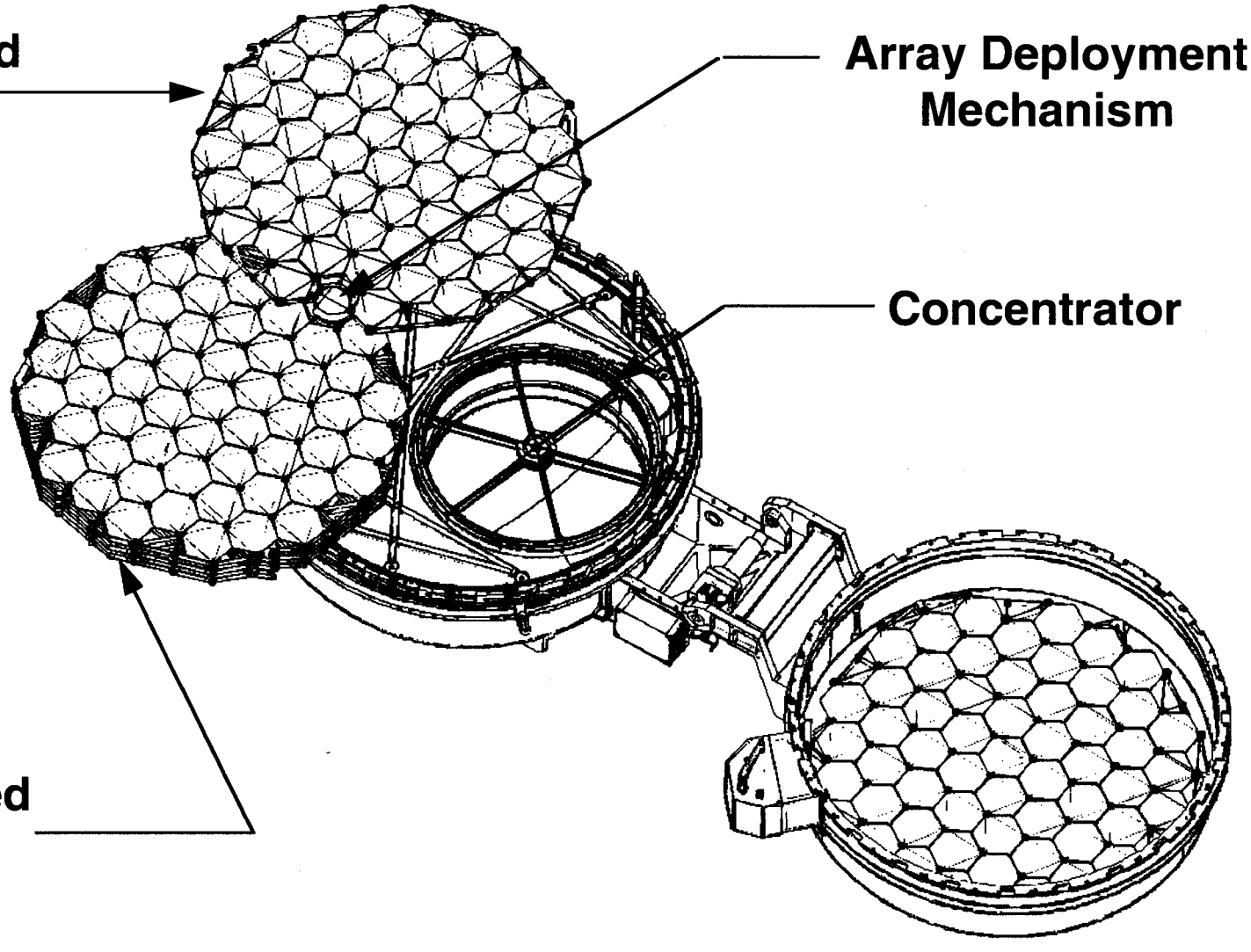
GENESIS
SEARCH FOR ORIGINS

Integrated Canister Cover Open



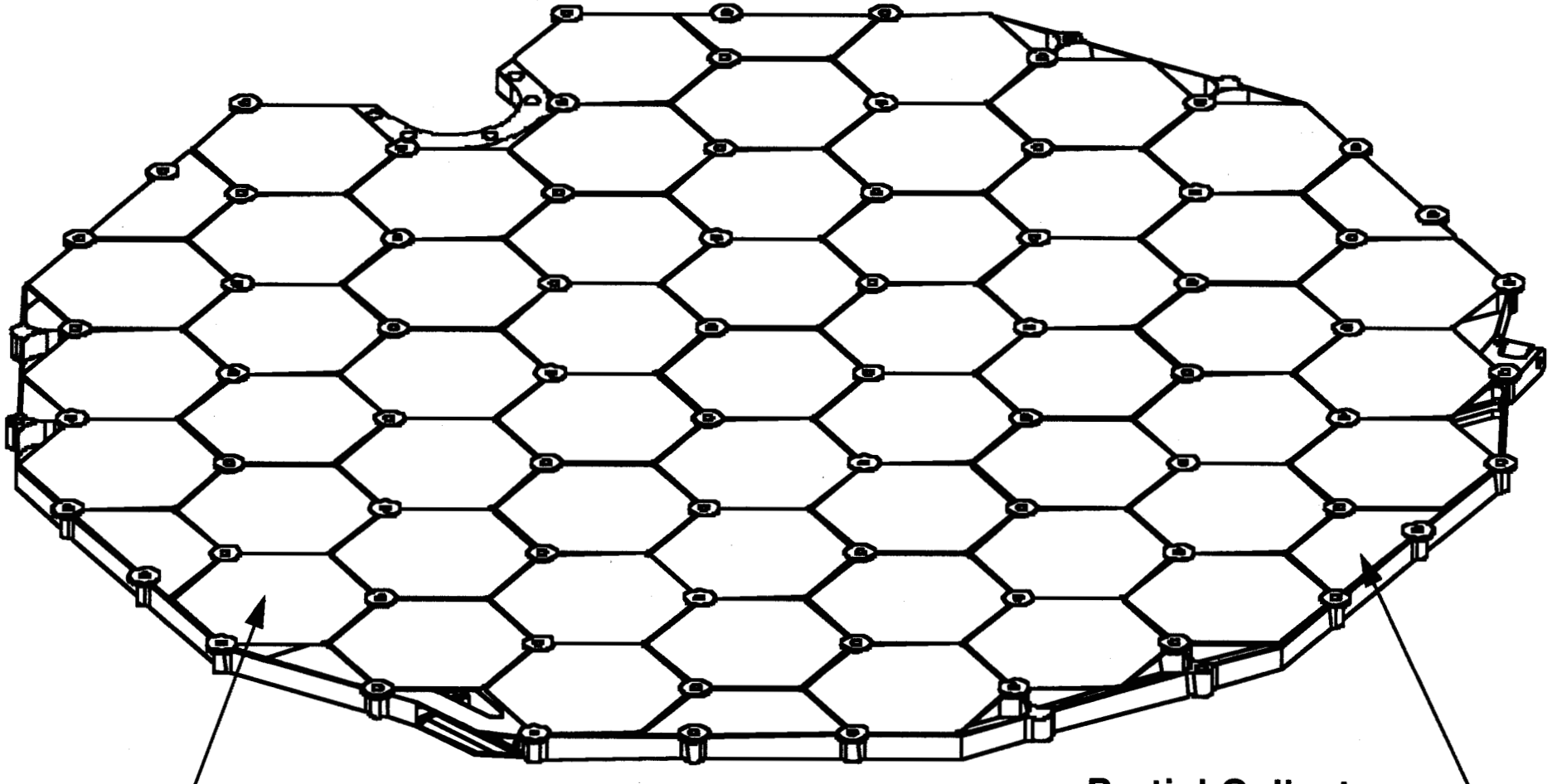
GENESIS
SEARCH FOR ORIGINS

Integrated Canister Deployed



GENESIS
SEARCH FOR ORIGINS

Array Assembly Including Partial Collectors

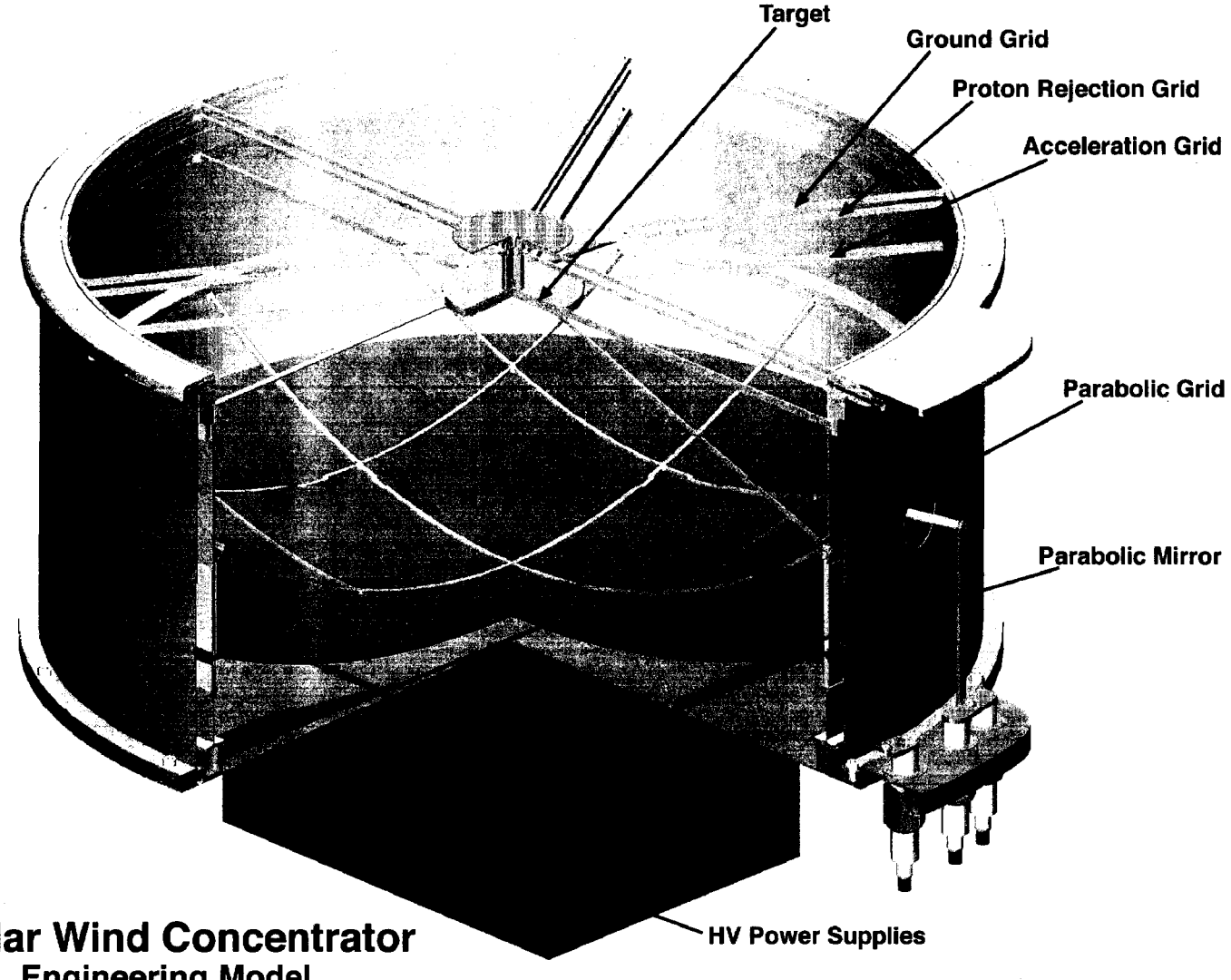


GENESIS
SEARCH FOR ORIGINS

Concentrator Design

- Average Concentration Factor for N and O Shall Be >20.
- Concentrator Target Area >15 cm^2.
- Concentrator Must Not Introduce $^{17}O/^{16}O$ Errors > 0.1%.
- Concentrator Target Temperature Not To Exceed 250°C.
- S.W. Ions Shall Be Accelerated > 8 kV Before Impacting the Concentrator Target.
- TBD %(Goal of 90%) of Solar Wind Proton Fluence Shall Be Prevented From Reaching Concentrator Target.

Payload Concentrator Assembly



Solar Wind Concentrator
Engineering Model

GENESIS
SEARCH FOR ORIGINS

Prototype Concentrator

Interior w/o Top Grids & MCP Mount

Complete Assembly w/MCP Mount

Side View w/Top Outer Can Removed

Side View w/Outer Can Removed

DRAFT

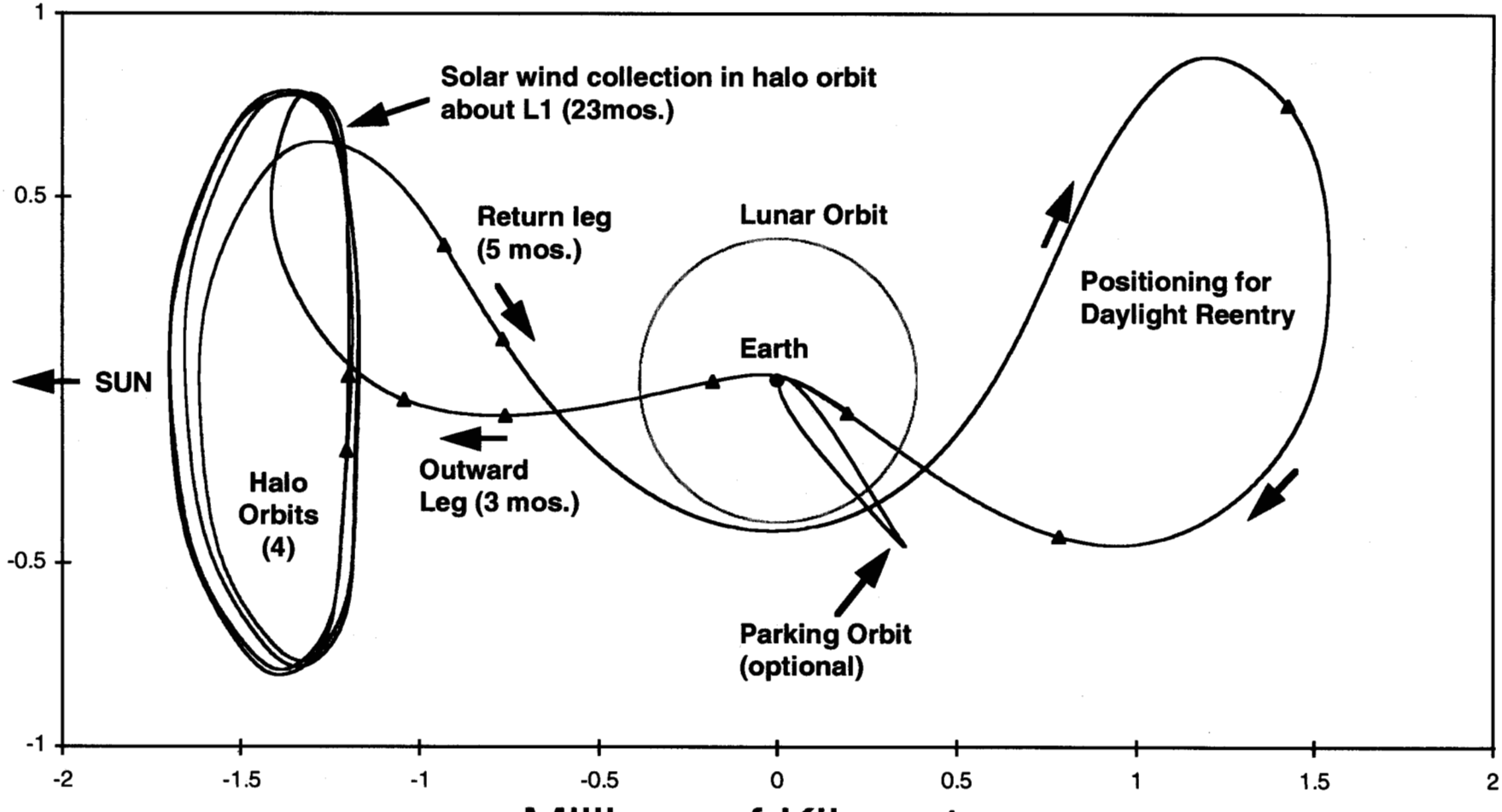
PART 3: The Mission

- Trajectory Design
- Spacecraft
- Sample Return Capsule (SRC)
- Sample Return
- Mission Operations System

DRAFT

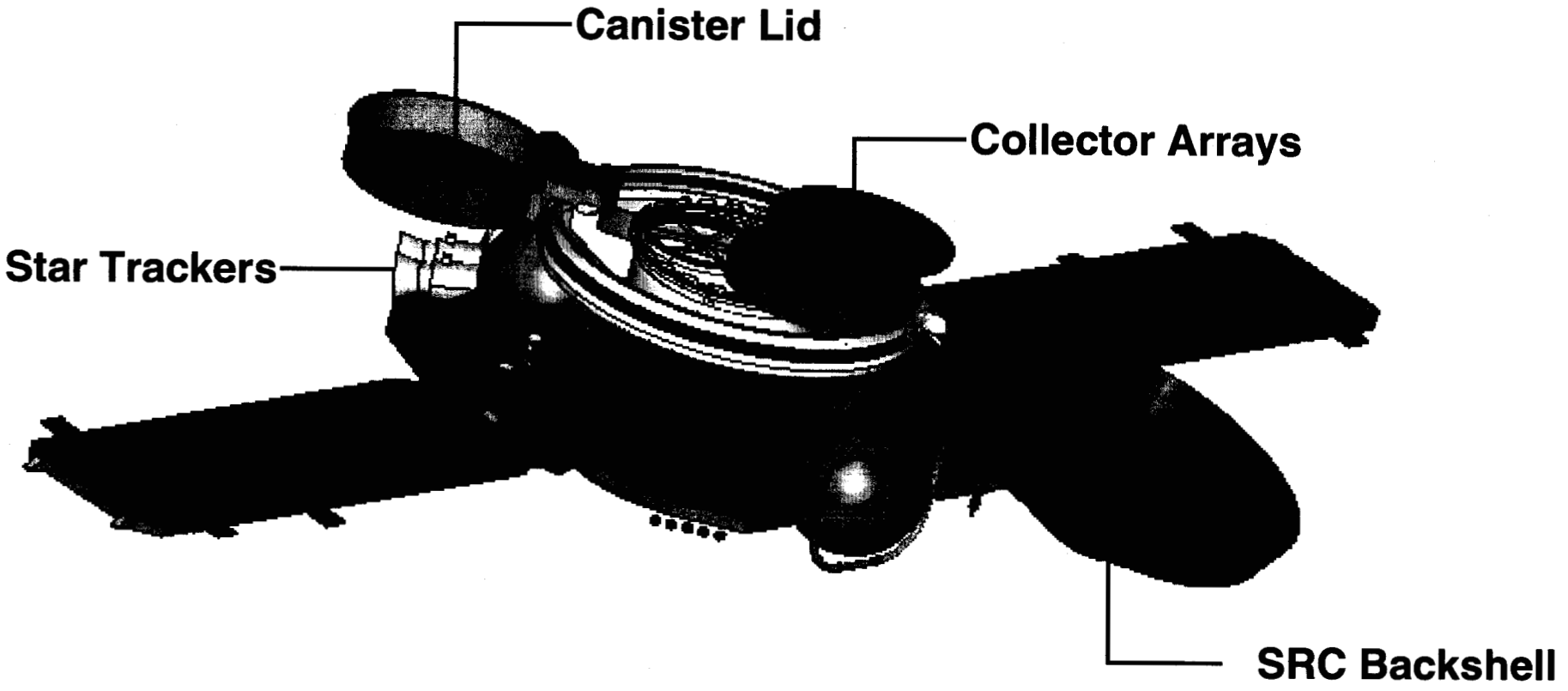
GENESIS
SEARCH FOR ORIGINS

How We're Doing Genesis



DRAFT

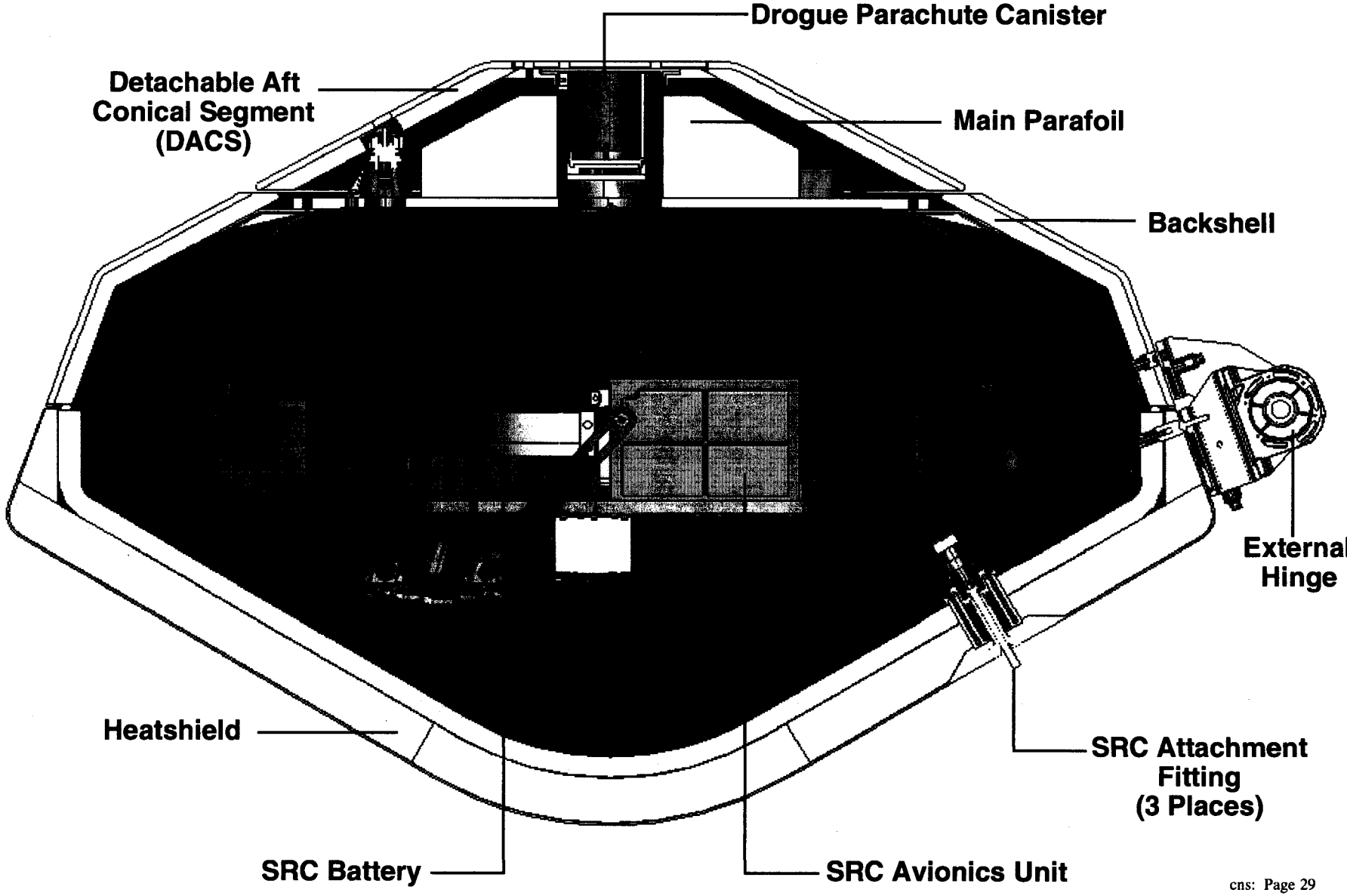
Flight System Science Config'n - Top



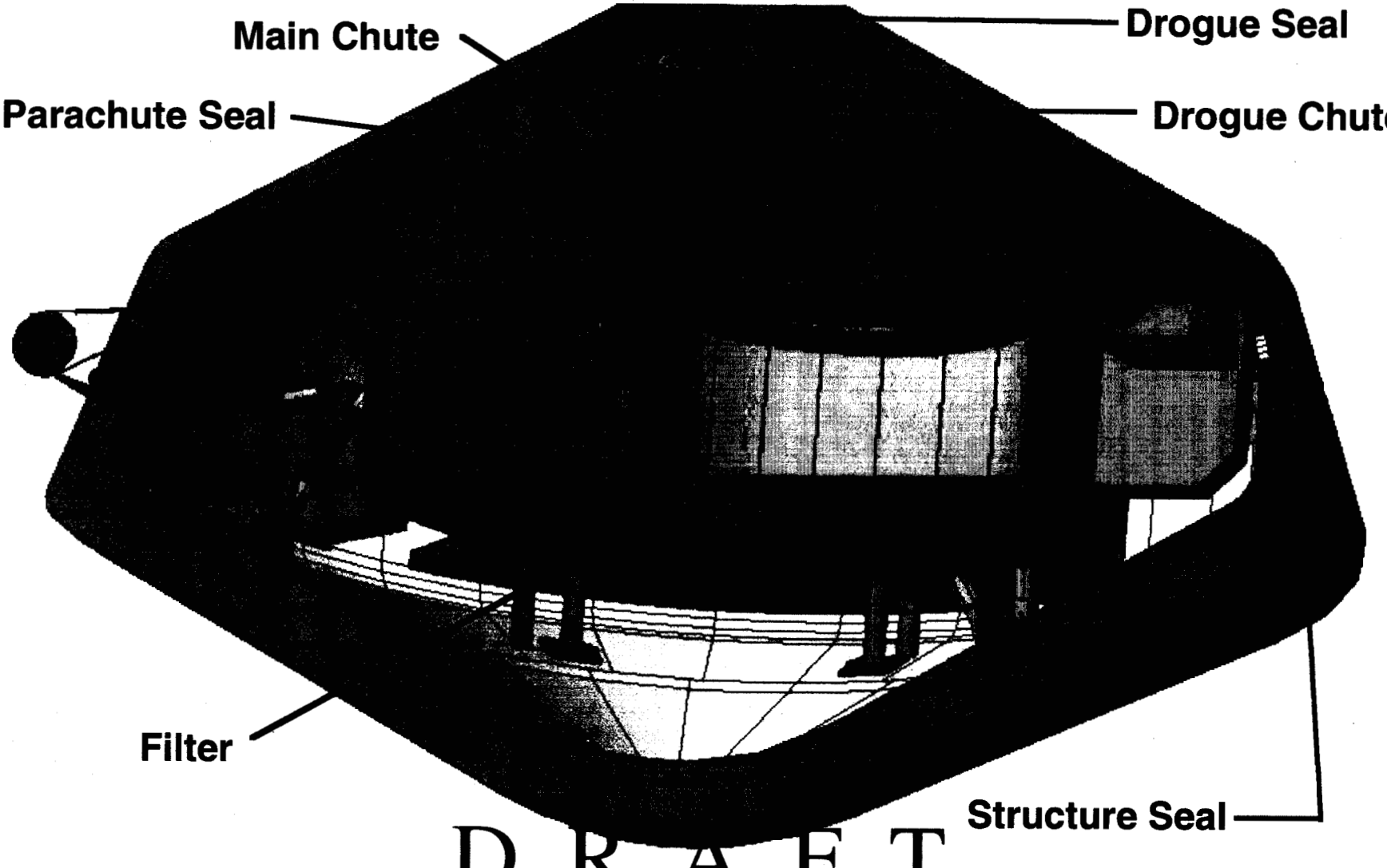
DRAFT

GENESIS
SEARCH FOR ORIGINS

Sample Return Capsule Cross-Section



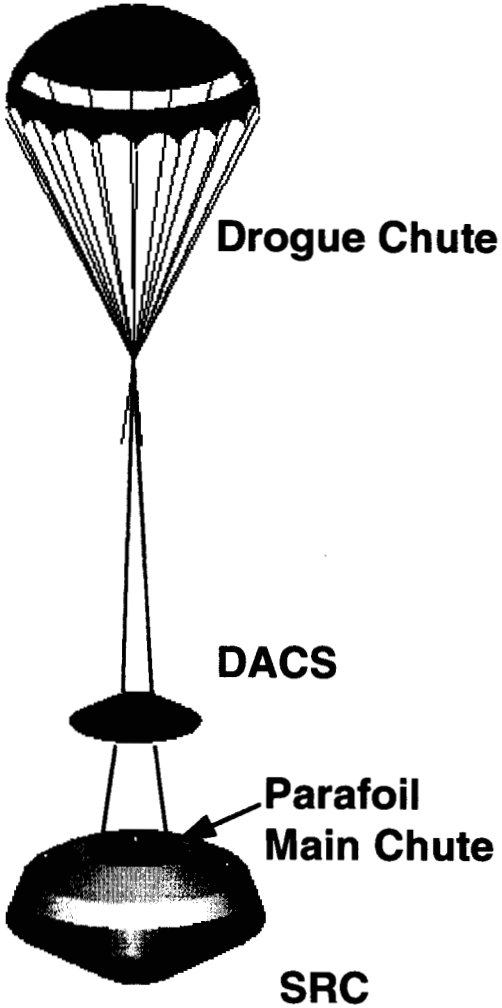
SRC Hardware



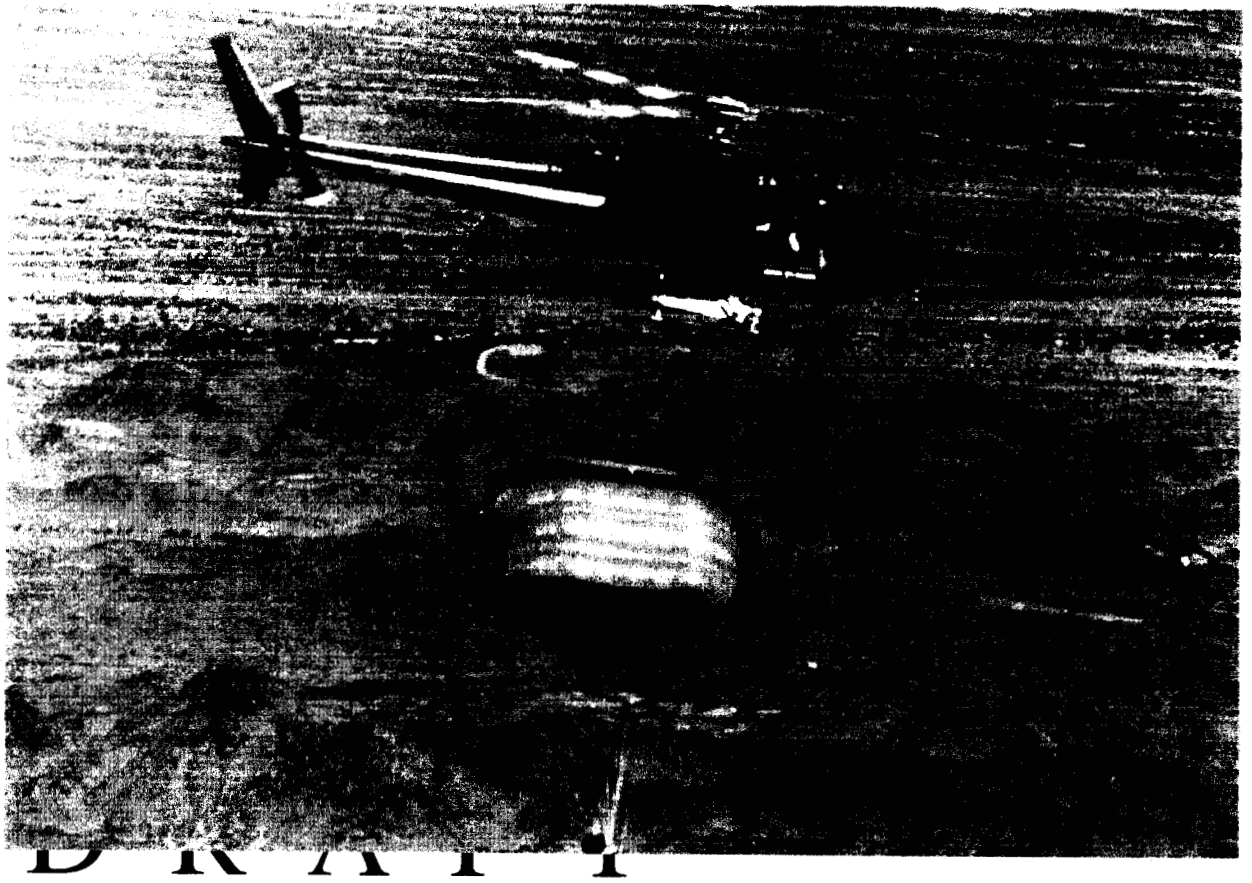
GENESIS
SEARCH FOR ORIGINS

Mid-Air Retrieval of SRC

DACS/Drogue Separation

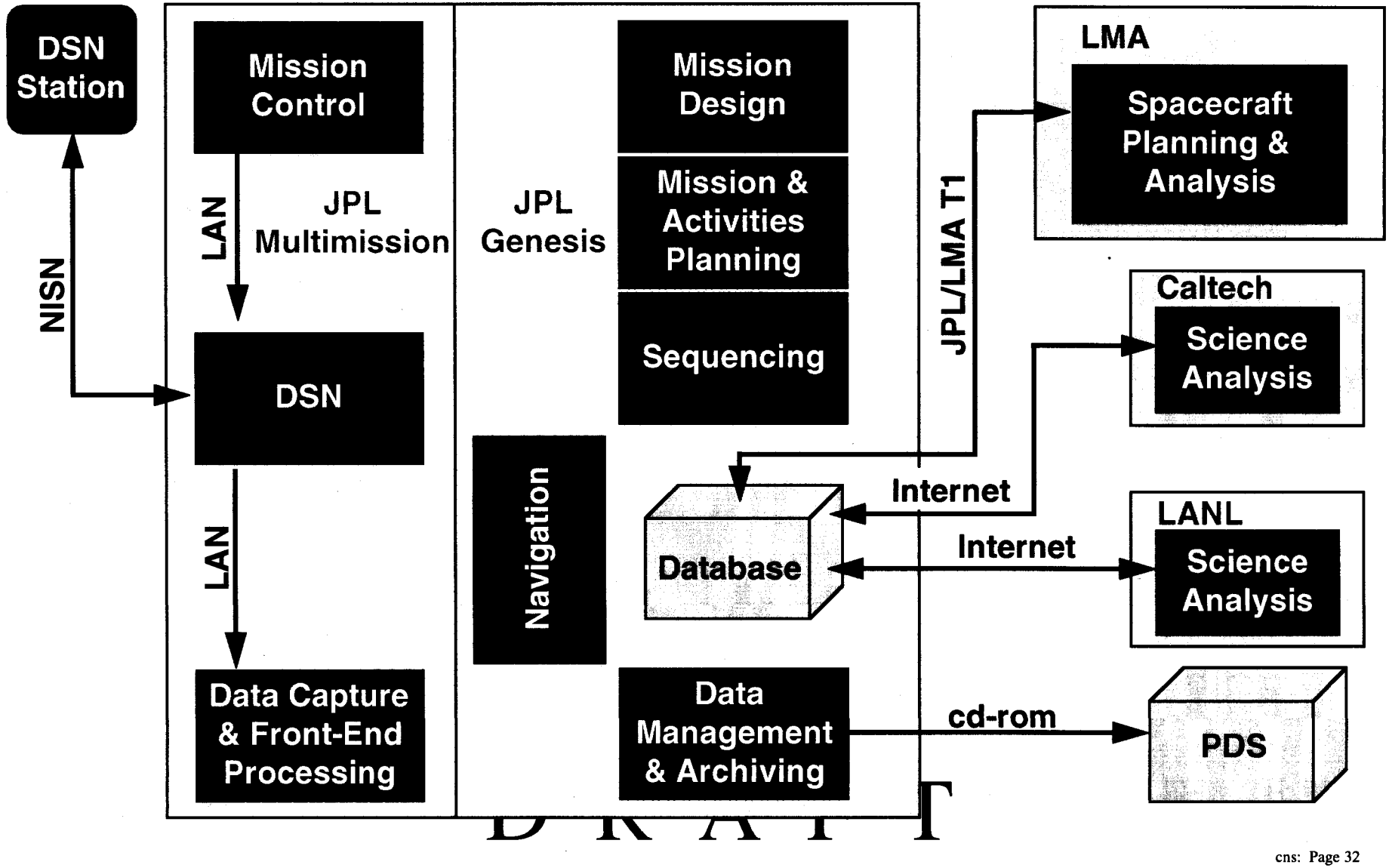


- Mid-air Retrieval Successfully Demonstrated



GENESIS
SEARCH FOR ORIGINS

Overview
NOMINAL GDS ARCHITECTURE



BACKUP

D R A F T

GENESIS
SEARCH FOR ORIGINS

Solar Wind Properties

- **Solar Wind is Essentially Constant Velocity**
  - Different masses have different energies and turn-around points. This is the source of mass fractionation.
  - Concentrator design now has energy independent focus
  - Simulated in test chamber by changing mirror electrode voltage with mass
- **Group Velocity Varies Between 300-800 km/s**
  - Mean velocity is ~440 km/s = 1 kev/amu
  - Coronal hole wind is significantly faster than other types
  - Ion monitor data used to optimize operation of H^+ rejection grid and mirror point
- **Ion Temperature Significant--Causes Spread in Velocity**
  - Causes an effective angular distribution as seen by the concentrator
  - Concentrator has wide field of view

Expected Solar Wind Abundances

Z	Element	Concentration (parts per million wt.)
3	Li	5.3×10^{-5}
4	Be	8.9×10^{-7}
5	B	3.1×10^{-5}
6	C	5.4×10^{0}
7	N	2.0×10^{0}
8	O	1.7×10^{1}
9	F	7.2×10^{-4}
	...	

Concentration of Solar Wind From 2-Yr Fluence Averaged Over Top 0.1 micron in Silicon

DRAFT